## REMARKS

In the February 25, 2005 Office Action, the Examiner rejected Claims 1, 3-9, 11-14, 16-21 and 23 under 35 U.S.C. § 103(a) contending that such claims were obvious based on U.S. Patent No. 5,754,714 to Suzuki et al. in view of U.S. Patent No. 6,091,864 to Hofmeister, U.S. Patent No. 6,396,605 to Heflinger et al. (Heflinger), and U.S. Patent No. 5,359,449 to Nishimoto et al. (Nishimoto). Applicant respectfully disagrees that the limitations of independent Claims 1, 8, 14, 21 and 23 as currently presented are obvious based on Suzuki in combination with Hofmeister, Heflinger and Nishimoto, and respectfully submits that independent Claims 1, 8, 14, 21, and 23, and all claims depending directly or indirectly therefrom are in condition for allowance.

As summarized more fully below, in each of the independent claims, an optical feedback signal is optically amplified to increase its optical intensity, the optical feedback signal is combined with an input light beam, and the combined optical signal is modulated in response to an electrical signal. The electrical signal is applied around a selected phase angle operating point of the optical modulator within a specified range of phase angles wherein a slope of a transfer curve relating relative optical intensity of an optical signal output by the optical modulator versus phase angle of the optical modulator is at least 0.087 per degree in order to output a high modulation depth optical signal.

More particularly, independent Claim 1 is directed to a high efficiency optical feedback modulator operable to produce a high modulation depth optical signal comprising an optical modulator and an optical feedback system. The optical modulator includes a first and a second optical input and a first and a second optical output. The optical feedback system couples the second optical output to the second optical input and is operable to communicate an optical feedback signal from the second optical output to the second optical input, and the optical feedback system includes an optical amplifier disposed between the second optical output and the second optical input, the optical amplifier being operable to increase an optical intensity of the optical feedback signal. The first optical input is operable to receive an input light beam and the optical modulator operates to modulate the input light beam and the optical feedback signal in response to an electrical signal applied around a selected phase angle operating point of the

optical modulator within a specified range of phase angles wherein a slope of a transfer curve relating relative optical intensity of an optical signal output by the optical modulator versus phase angle of the optical modulator is at least 0.087 per degree to output the high modulation depth optical signal from the first optical output.

Independent Claim 8 is directed to a high efficiency optical feedback modulator comprising an optical modulator and an optical feedback system. The optical modulator includes at least two optical inputs and at least two optical outputs, an input light beam being receivable on at least one of the optical inputs. The optical feedback system is configured to feed an optical feedback signal from at least one of the optical outputs to at least one of the optical inputs, and the optical feedback system includes an optical amplifier disposed between the at least one of the optical outputs and the at least one of the optical inputs, the optical amplifier being operable to increase an optical intensity of the optical feedback signal. The optical modulator includes a first optical coupler wherein the input light beam is combined with the optical feedback signal to produce first and second optical signals. The optical modulator is operable to modulate the first and second optical signals in response to an electrical signal to produce first and second phase shifted optical signals, the electrical signal being applied around a selected phase angle operating point of the optical modulator within a specified range of phase angles wherein a slope of a transfer curve relating relative optical intensity of an optical signal output by the optical modulator versus phase angle of the optical modulator is at least 0.087 per degree. The optical modulator includes a second optical coupler wherein the first phase shifted optical signal is combined with the second phased shifted optical signal to produce the optical feedback signal and a high modulation depth optical signal.

Independent Claim 14 is directed to a fiber optic system comprising a high efficiency optical feedback modulator operable to receive an electronic input signal, an optic fiber coupled to an optical output of the optical modulator and operable to communicate a high modulation depth optical signal, and an optical receiver operable to receive the high modulation depth optical signal and convert the high modulation depth optical signal into an electronic output signal. The high efficiency optical feedback modulator includes an optical modulator having at least two optical inputs and at least two optical outputs and an optical feedback system feeding an optical feedback signal from at least one of the optical outputs to at least one of the optical inputs. The

optical feedback system includes an optical amplifier disposed between the at least one of the optical outputs and the at least one of the optical inputs, the optical amplifier being operable to increase an optical intensity of the optical feedback signal. The optical modulator is operable to receive an input light beam on at least one of the optical inputs, combine the optical feedback signal with the input light beam, and modulate the combined input light beam and optical feedback signal in response to the electronic input signal applied around a selected phase angle operating point of the optical modulator within a specified range of phase angles wherein a slope of a transfer curve relating relative optical intensity of an optical signal output by the optical modulator versus phase angle of the optical modulator is at least 0.087 per degree to produce the high modulation depth optical signal.

Independent Claim 21 is directed to a method for producing a high modulation depth optical signal comprising the steps of communicating an input light beam to a first optical input of an optical modulator, communicating an optical feedback signal from a second optical output of the optical modulator to a second optical input of the optical modulator, wherein an optical intensity of the optical feedback signal is amplified prior to communicating the optical feedback signal to the second optical input of the optical modulator, coupling the input light beam with the optical feedback signal to produce a first and a second optical signal, intensity modulating at least one of the optical signals in response to an electronic input signal applied to an optical modulator to produce a first and a second phase shift optical signal, the electronic input signal being applied around a selected phase angle operating point of the optical modulator within a specified range of phase angles wherein a slope of a transfer curve relating relative optical intensity of an optical signal output by the optical modulator versus phase angle of the optical modulator is at least 0.087 per degree, and coupling the phase shift optical signals to produce the high modulation depth optical signal and the optical feedback signal.

Independent Claim 23 is directed to a high efficiency optical feedback modulator comprising an optical modulator and an optical feedback system. The optical modulator includes at least two optical inputs and at least two optical outputs. The optical feedback system couples at least one of the optical outputs to at least one of the optical inputs, and the optical feedback system includes an optical amplifier disposed between the at least one of the optical outputs and the at least one of the optical inputs, the optical amplifier being operable to increase an optical

intensity of the optical feedback signal. The optical modulator comprises a Mach-Zehnder two-by-two optical modulator comprising a first and second optical input, and a first optical output that is the complement of a second optical output. The optical feedback system couples the second optical output to the second optical input. The optical modulator modulates an input light beam received on the first optical input and an optical feedback signal received on the second optical input in response to an electronic input signal applied around a selected phase angle operating point of the optical modulator within a specified range of phase angles wherein a slope of a transfer curve relating relative optical intensity of an optical signal output by the optical modulator versus phase angle of the optical modulator is at least 0.087 per degree to output a high modulation depth optical signal.

The combination of Suzuki, Hofmeister, Heflinger and Nishimoto do not render obvious to one skilled in the art the various combinations of limitations required by independent Claims 1, 8, 14, 21 and 23 because together, Suzuki, Hofmeister, Heflinger and Nishimoto fail to teach or reasonably suggest optically amplifying an optical feedback signal to increase its optical intensity, combining the optical feedback signal with an input light beam, and modulating the combined optical signal in response to an electrical signal that is applied around a selected phase angle operating point of the optical modulator within a specified range of phase angles wherein a slope of a transfer curve relating relative optical intensity of an optical signal output by the optical modulator versus phase angle of the optical modulator is at least 0.087 per degree in order to output a high modulation depth optical signal.

In this regard, Fig. 7 of Suzuki depicts a Mach-Zehnder interferometer type optical switch that switches a signal light pulse that enters the switch through an input terminal 11 of an input optical coupler 1 between one of two output terminals 13, 14 of an output optical coupler 2 based on the presence or absence of a control light pulse that enters the switch through a first polarization coupler 3 and exits via a second polarization coupler 4. In the absence of the control light pulse, all signal output comes out of the first output terminal 13 of the output optical coupler 2. When a control light pulse is introduced to the first polarization coupler 3 in synchronism with the signal light pulse introduced into the input optical coupler 1, the signal output of the output optical coupler 2 is switched to the second output terminal 14 of the output optical coupler 2. (See e.g., Suzuki, Col. 19, lines 1-28 and 49-65). However, the first or the second output terminals 13, 14 are not shown or

described as being coupled back into the input optical coupler 1 or the first polarization coupler 3. Thus, no portion of the signal output from either of the output terminals 13, 14 is fed back into the switch depicted in Fig. 7 of Suzuki. This makes Suzuki's optical switch fundamentally different from Applicant's invention, since in accordance with Applicant's invention, the optical feedback signal is taken from an output of the modulator, optically amplified, and fed back into the modulator.

Fig. 4 of Hofmeister depicts an optical modulator having a first stage interferometer 102 coupled to a substantially similar second stage interferometer 116 in which respective first and second stage electrode structures 108, 124 are coupled to respective first and second RF inputs RF1, RF2 for receiving respective first and second RF modulating voltages and respective associated biases α1, α2. (See e.g. Hofmeister, Col. 7, line 20 through Col. 8, line 16). The optical modulator of Hofmeister uses optical predistortion to maximize linearity and produce optical signals having substantially no modulator chirp. (See e.g. Hofmeister, Col. 2, lines 40-43). However, Hofmeister does not disclose feeding an optical signal output from one of the outputs of the optical modulator into one of its inputs, nor does Hofmeister disclose optically amplifying an optical feedback signal to increase its optical intensity prior to feeding it back into one of the optical inputs of the optical modulator.

In Fig. 1, Heflinger depicts an apparatus 10 that uses an optical signal to tune an optical interferometer that includes means 14 for generating the optical signal, means 12 for generating an electronic dithering signal, an optical interferometer 18 having one leg 20 with an electronically tunable optical path length, and means 16 for applying a portion of the electronic dithering signal to the optical signal so as to provide an optical signal having a varying wavelength in accordance with the electronic dithering signal. The apparatus 10 of Fig. 1 also includes an opto-electronic receiver 24 that develops an electronic feedback signal in the presence of an interference pattern different from a first interference pattern developed by interferometer 18 when the optical path length is electronically tuned to a prescribed value corresponding to a particular electronic drive adjustment signal. The apparatus 10 of Fig. 1 further includes means 28 responsive to a portion of the electronic dithering signal conveyed thereto by means 16 and the electronic feedback signal conveyed thereto by means 26 to produce the electronic drive adjustment signal that is conveyed by means 45 to an electronic optical path length controller 46 which drives an optical path length tuning element means 48 to changes to optical path length of the leg 20 of the interferometer 18. (See e.g., Heflinger, Col.

3, line 54 to Col. 4, line 34). Thus, Heflinger discloses the use of an electronic feedback signal in conjunction with an electronic dithering signal to control the optical path length of an optical interferometer. More significantly, Heflinger does not teach optically amplifying an optical feedback signal to increase its optical intensity and subsequently feeding the optical feedback signal into one of the optical inputs of an optical modulator.

In Fig. 13 of Nishimoto, an embodiment of an optical transmitter is depicted having branching waveguides 6, 8, a driving circuit 76, and an inverting circuit 78 including an operational amplifier 86. A bias voltage Vb is fed to a bias electrode 16A that applies bias voltage Vb to branching waveguide 6. The bias voltage Vb is also supplied to inverting circuit 78 which inverts bias voltage Vb and feeds inverted bias voltage Vb to a bias electrode 16B that applies inverted bias voltage Vb to branching waveguide 16B. Applicant respectfully submits that contrary to the Examiner's contention on page 3 of the Office Action, feedback and amplification of an optical feedback signal from between an optical output of an optical modulator and an optical input of the modulator is absent from Nishimoto, and Fig. 13 in particular thereof. In short, Nishimoto does not teach optical amplification of an optical feedback signal.

Thus, due to the significant differences noted above, Suzuki simply cannot be combined with Hofmeister, Heflinger and Nishimoto to achieve Applicant's invention as claimed in each of independent Claims 1, 8, 14, 21 and 23. Furthermore one skilled in the art would not be motivated to combine Suzuki with Hofmeister, Heflinger and Nishimoto even if the necessary portions of Applicant's invention were disclosed thereby. Suzuki is directed to addressing an entirely different problem within optical communication networks than Applicant's invention. Suzuki is concerned with switching an input optical signal, which may or may not have previously been modulated, on different output paths within an optical network.

In contrast, Applicant's invention is concerned with modulating an optical signal according to a time-varying electrical input signal in a manner that produces greater variation in optical intensity (i.e. high modulation depth) than with conventional optical modulators, thereby permitting information in the time-varying electrical input signal to be, for example, subsequently transmitted within an optical network with fewer transmission errors as compared with low modulation depth optical signals output by conventional optical modulators. In this regard, Applicant's invention achieves an enhanced modulation depth relative to conventional

optical modulators that operate without optical feedback and optical amplification of the optical feedback by applying the electronic input signal in a small-signal sense around a particular phase angle operating point (or DC bias point) of the optical modulator wherein the slope of the transfer curve relating relative optical intensity of an optical signal output by the optical modulator versus phase angle of the optical modulator is nearly vertical (e.g. at least about 0.087 per degree). The more vertical the slope of the transfer curve, the more efficient the optical modulator is in producing a large output optical intensity variation for a given input electrical amplitude variation. As the gain of the optical feedback circuit is increased, the slope of the transfer curve becomes more vertical until just before oscillation. A comparison of the transfer characteristic of a conventional Mach-Zehnder optical modulator and a high efficiency optical feedback modulator in accordance with the present invention is illustrated in FIG. 5 of the application. As shown in Fig. 5, the slope efficiency of the current invention indicated by 94a significantly exceeds the slope efficiency of a conventional modulator indicated by 94b. Clearly, the use of optical feedback and amplification in accordance with Applicant's invention results in a substantial improvement in the effectiveness of an optical modulator, estimated at 10 or better depending on the optical gain, resulting in a RF link gain improvement by a factor of 100. See e.g., Application page 12, lines 19-25.

In view of the significant advantages achieved by Applicant's invention and since, Applicant's invention and Suzuki are directed to addressing different problems within optical networks, one skilled in the art would therefore not be motivated to combine Suzuki with Hofmeister, Heflinger and Nishimoto to achieve Applicant's invention.

Based upon the foregoing, pending independent Claims 1, 8, 14, 21, and 23 as well as their corresponding dependent claims are allowable over the combination of Suzuki, Hofmeister, Heflinger and Nishimoto. There is therefore no need to separately address the patentability of each dependent claim and/or the Examiner's interpretation in relation to any of the dependent claims or any of the references of record in relation thereto.

Conclusion:

In view of the foregoing, Applicant believes that all pending claims are in condition for allowance and such disposition is respectfully requested. In the event that a telephone conversation would further prosecution, the Examiner is invited to contact the undersigned.

Respectfully submitted,

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